ICES Theme Session B

The science and tools for management of networks of marine protected areas

Conveners: Henrique Queiroga, Helen Bailey, Elsa Otero

Average attendance

40-50 people

Session synopsis

Networks of Marine Protected Areas (MPAs) are effective and consensual tools to protect the marine environment in the face of biodiversity loss, pollution, overfishing and climate change. MPAs provide a buffer against acute and diffuse environmental disturbances, by protecting different levels of biological organization (genes, species and habitats) and of ecological processes (biogeochemical cycles, trophic web flows, reproduction and population replenishment). Networks of MPAs are a fundamental part of larger frameworks of ecosystem-based management, integrated ocean governance and coastal zone management, which are emerging under the general designation of Ecosystem-Based Marine Spatial Planning.

Although the theoretical basis and rationale for setting networks of MPAs already exists, operational principles and guidelines described in binding agendas present a variable mix of ecological criteria and management approaches. This is partly related to important knowledge gaps on habitat characterization, extent of ecologically significant population units, life cycle data, genetic variability and trophic interactions. An increased understanding of spatial patterns and processes will play a central role in integrated ecosystem assessments, marine spatial planning and determining the influence of human activities on marine species and habitats. Seascape ecology is an emerging tool that focuses on the spatial patterns, processes, and ecological functions associated with marine species and communities, by quantitatively analysing their spatial distributions in the context of dynamic environmental forcing, allowing insights into the multi-scale processes that drive species distributions and biodiversity.

In many instances, understanding of the effects of the MPAs themselves is obstructed also by poor design and monitoring, which affects the perception of benefits by scientist, managers, policy makers and the public. A further level of complexity is brought about by the various levels of organization and their empowerment within existing political frameworks, and on the decision mechanisms, scientific expertise and biogeophysical setting pertaining to each level of organization and spatial scale.

Overview and themes of papers

1. Movement corridors and connectivity (B1-4)
2. Use of telemetry (acoustic and satellite) to understand animal movements.
3. Chemical methods e.g. mussel shell geochemistry.
4. Numerical modeling of larval dispersal.
5. Species distribution and habitat models (B5-9)
6. Baseline information often lacking.
7. Importance of biotic and abiotic factors.
8. Environmental factors can be static as well as dynamic. Dynamic sources include ocean models and satellite-derived products.
9. Design, implementation and management of MPAs (B10 and B11)
10. Most often qualitative goals are established for MPAs.
11. Adaptive management (B12-15)
12. Requires monitoring. Crucial for management.
13. Spatial and temporal scales are very important.
14. Population modelling indicates that the time to necessary to detect MPA effects is typically twice the generation time of the species of interest.
15. MPAs in practice (B16-20)
16. Two examples off the Isle of Man of the success of a cooperative approach to fishing and fisher involvement.
17. Example off Germany where little information on species for which MPA was designated and difficulty of satisfying stakeholders regarding fishery restrictions.
18. Use of Before-After-Control-Impact (BACI) technique to assess effectiveness of MPA on increasing fish density on Georges Bank. At the MPA scale differences in biomass were detected for some of the species. A network effect was detected in one of the species.

Conclusions

In many cases, the MPA was not designated for the species of interest in the studies described and suggests there were additional ecological benefits of the MPAs. MPAs were often designated based on scarce baseline information. Additional information, such as video surveys and telemetry, can provide important information on habitat suitability and dispersal. Species distribution models provide insight into the habitat suitability of MPAs. The papers highlighted the importance of biotic and abiotic factors for understanding species distributions. Management plans for MPAs often contain qualitative objectives. MPA management was most successful when fishermen and other stakeholders were involved in the process. Regular monitoring is key for determining the effectiveness of MPAs and adaptive management. Most studies focused on single MPAs and there was relatively little information on networks of MPAs. Moving toward the target of 20% of the ocean included in any kind of protected area translates into an effective overall reduction of fishing mortality; how do stock assessment and management methods incorporate this refuge effect? This highlights the need for further theoretical and applied research on networks of MPAs.

Papers of exceptional merit

There were four papers in our session that we considered of exceptional merit because of their relevance to determining the effectiveness of MPAs and implications for their management.

B:07 David Abecassis – Combining multispecies home range and distribution models to evaluate the optimal design of MPAs

Adequate design and management of MPAs is dependent on the quality of baseline information. Acoustic telemetry provides relevant information, such as home range and site fidelity. In this study they used acoustic telemetry and environmental explanatory variables to create species distribution models. They assessed the effective protection provided by the Luiz Saldanha MPA. Study species were white seabream (tagged 20), cuttlefish (tagged 7) and Senegalese sole (tagged 17). Maximum monitoring duration was 293 days and the mean home range 0.7-1.19 km2. Explanatory variables were habitat type, depth, aspect, slope, curvature and distance to rocky bottom. Used Maxent modeling for the species distribution model, which requires presence data only. Acoustic telemetry used as the training data set, and visual census and experimental fishing as the independent test data sets for validation. For cuttlefish, nearly 70% of the MPA is suitable, but there is a much greater area outside the MPA that is also suitable. About 23% of the no-take area is suitable for this species. Acoustic telemetry data is a useful tool. The combined use of species distribution models and home range data provided a better insight into the true potential of MPAs, the size and location where protection is most effective, and quantitative estimation of the fishing vulnerability throughout the MPA.

B:12 Louis Botsford – Adaptive management based on monitoring of marine protected areas in California

MPAs cover about 15% of the coastline off California. Adaptive management can be viewed as determining whether populations are responding as predicted. Age truncation by fishing means early response of the MPA will be filling in the age structure. This increase in abundance will depend on fishing and natural mortality rates. Response to a single MPA depends on distance from the MPA. Age truncation also leads to filling in of size distribution because of MPAs. Size distributions are used to estimate local fishing mortality rate. Showed recruitment variability of related rockfish populations. Simulations illustrate difficulty in detecting MPA effect on abundance. Requires >15 years to detect MPA effect for rockfish (originally expected 5 years). It is related to generation time, and was estimated in this case to be twice the generation time. Spatial scale approximately twice the larval dispersal distance. In a comparison with empirical observations there was no indication yet of response in abundance of fish since MPA implementation in 2007. Global need for adaptive management of MPAs and to monitor to determine effectiveness of MPAs.

B:16 Isobel Bloor - Baie ny Carrickey Closed Area: Managing fishermen to manage marine protected areas

Isle of Man MPA network protects about 5% of Manx waters. Port Erin closed area was initiated as a scallop research area and evolved into a fisheries management tool. The Douglas closed area is a scallop recovery area. Niarbyl and Laxey areas are for scallop protection. Baie ny Carricky closed area of 11km2 was designed by a stakeholder committee. It is closed for mobile gear (scallop fishing) for up to 20 years. Protects seabed (kelp forests and rocky reefs). Also protects commercial crustacean populations. The Baie ny Carricky Association is composed of 7 commercial crustacean fishermen and they designed the plan for data collection and management by fishermen. Their aim is to maintain ecological integrity, and maintain and enhance commercial fisheries resources. Data collection by camera systems. Scientists analyze the videos to determine carapace length, width, sex, berried status and diseases of catch. Provides baseline data set that is collected by the fishermen. Habitat mapping was conducted using a flying array that is towed behind the fishing vessel. Scientists analyze the data e.g. calculating if increase MLS for lobsters from 88mm to 90mm what percentage of catch would be lost. The trial is 1 year through its full 3 year period. If effective the scheme could be considered by the government in other areas around the Island.

B:20 Steven Cadrin – A question of scale: Evaluating the impact of marine protected areas off of New England on groundfish productivity

A network of MPAs was established in New England when several groundfish species collapsed and were in need of rebuilding. Closed area I and II were established to reduce fishing mortality and protect haddock spawning. Nantucket lightship was closed to reduce fishing mortality and enhance spawning potential of yellowtail flounder. The Western Gulf of Maine was closed to reduce mortality of Gulf of Maine cod. The Cashes Ledge closure was for general groundfish rebuilding. Data from biannual (spring/autumn) stratified random bottom trawl surveys. Performed a BACI (before-after-control-impact) study design. Before-After were in equal time periods before and after the establishment of the MPAs. Control-impact were inside and outside the boundaries of closed areas. There is no true control for these impacted sites. Used spillover buffer of 4km, which was excluded from the analysis. Outside data matched the same strata within closed areas. Two approaches to defining control area: area outside spillover buffer (>4-19km), and area outside mean distance of fish movements. Statistical approach using GLM with a mixed discrete-continuous distribution. The discrete portion models the probability of fish occurrence and the continuous portion models positive catch of fish. Closed Area II was effective in increasing productivity of Atlantic haddock. BACI analysis indicated no significant impact of MPA on cod. No significant impact of MPAs on yellowtail flounder biomass. At network scale differences in biomass were detected. Network view captured more of the spatial pattern. The spatial distribution suggests closures may have generated benefits outside of the MPA. The perception of MPA effectiveness depended on spatial and temporal scales of investigation and on species. The statistical distribution of survey data and outliers presented challenges. MPA responses may vary so closed area effect is contained within the borders or spills over through larval or post-settlement dispersal. Requires comprehensive evaluation of the MPA at different scales for robust assessment of MPAs in achieving management goals. Investigating other single species and ecosystem responses associated with MPAs would also be valuable.

Conclusions

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